Ecosystem health: ecological sustainability target of strategic environment assessment

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Abstract: Strategic environment assessment (SEA) and ecosystem health are two new ideas on environmental management. On the basis of reviewing some relevant literature, this paper made discussions on the ecological sustainability target of SEA, the content of ecosystem health as well as the interrelations between SEA and ecosystem health. For a good SEA, its ecological sustainability principles should be provided with distinct content and a general assessment system. A framework for ecosystem health assessment was established according to the content of ecosystem health, and combined into SEA as SEA's ecological sustainability target, we can effectively guide decision-makers to make suitable indigenous means and local solutions. , The basic principles and procedure of SEA for ecosystem health are also discussed in the paper.

Keywords: Environment impact assessment; Strategic environmental assessment; Ecosystem health

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Introduction

Recently, as the deficiencies of environmental impact assessment (EIA) are recognized and the implementation of a sustainable development strategy becomes imperative, more attention has been being paid to the research on strategic environmental assessment (SEA), which is regarded as one of important supporting tools for implementing sustainable development strategy (Leppard *et al.* 1992). It is widely recognized that SEA should follow sustainability principles. By summarizing the (P.R.C) domestic and foreign research on strategic environmental assessment (Shepherd 1996; Costanza 1997; ECMT 1998; Liu 2001; Kong 2002), we found that researchers pay more attention to that how SEA is implemented according to sustainability principles and how SEA promotes human sustainable development. In fact, sustainable development includes three basic elements: social sustainability, economic sustainability, and ecological sustainability Among the three elements, ecological sustainability is the most fundamental one but the ecological sustainability target of SEA has been scarcely discussed in most literature, which undoubtedly has hindered further research and effective implementation of SEA. With popularity of SEA, ecosystem health, a new perspective of human ecological sustainability, has been put forward (Rapport 1998; Liu 2001). However whether ecosystem health can be the ecological sustainability target of SEA remain a question, and this question is rarely discussed in recent literature.

This paper makes discussions on the concept of SEA and analyzes the ecological sustainability target of SEA, In addition, on the basis of reviewing some literature related to ecosystem health discussing the content of ecosystem health a framework for ecosystem health assessment has been put forward.

Strategic environmental assessment (SEA): a new idea for environmental impact assessment (EIA)

Birth and concept of SEA

Through research and practice for over 30 years, we had recognized that project-level EIA has unavoidable shortcomings (Leppard 1992; Steedman 1994), which makes it difficult to satisfy the requirements of harmonious development between the economy and the environment development. To counteract the limitations of project-level EIA, the concept of SEA was introduced into assessment system. SEA is a systematic and comprehensive process for assessing the environmental impacts of strategic decisions--policy, plan and program. It can provide the technical support for the formulation and implementation of these decisions (EMCT 1998).

Ecological sustainability target of SEA

As SEA is a means of environmental assessment that integrates with environment, society and economy in different decision levels, so as to put forward the optimum scheme of strategic decision and measures to manage pollution by analyzing the cumulative environmental impact, it may be thought that SEA's target is to promote sustainable development. As same as the sustainable development, SEA's target is also made up of three basic elements: social sustainability, economic sustainability, and ecological sustainability. Ecological sustainability, among these three targets, is the most fundamental target, which plays a cru-

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cial role to the other two targets, and it is important and significant to exploring ecological sustainability target of SEA. It has been widely recognized that SEA should be based on ecological sustainability principles and then encourage indigenous to achieve ecological sustainability target. There is no doubt that distinct and operational ecological sustainability principles can play an important role in making suitable indigenous means and local solutions. It is thought that good ecological sustainability principles should be provided with distinct content capable to reflect "ecological sustainability" and a general assessment system capable to guide specific assessment.

Ecosystem health: a new perspective of human ecological sustainability

Concept and content of ecosystem health

Ecosystem health is a kind of function manifestation in ecosystem operation, which can ensure ecosystem to develop well. The content of ecosystem health was firstly put forward by Rapport, D.J. in 1998. He thought that ecosystem health means that an ecosystem has possessed stability and sustainability, that is, it has possessed an ability to keep its organization, regulate itself and restore to the coercion, and that ecosystem health can be defined by the three characteristics of vigor, organization and resilience. Vigor reflects the function of ecosystem and can be surveyed by metabolism or primary productivity; organization can be evaluated by the interactive variety and its number among every kind of sections of ecosystem; resilience can be surveyed by the maintaining degree and time of the structure and function (Liu *et al.* 2001).

The core content of healthy ecosystem is the healthy structure and healthy function of ecosystem, and to know the structure and function of ecosystem, the formation, progressing process, characteristic and developing law of ecosystem, and the interactive system between ecosystem and environmental elements must be known (Rapport *et al.*1998).

From the concept and content of ecosystem health, ecosystem health provides a new perspective to know human ecological sustainability.

Assessment system of ecosystem health

A healthy ecosystem should be stable and sustainable, and can keep its organization and inner regulation both in time and in space (Kong *et al.* 2002). A healthy ecosystem possesses the extremely powerful capacity and resilience to coercive elements, so the most important assessment index for ecosystem health should be the ecosystem's integrity, adaptability and efficiency. The capacity and resilience to coercive elements may be shown in many fields. For example, the forest ecosystem's health can be appraised by the ability of self-renovation, ability of resisting marginal effect, sustainable ability of food chain in the system, maintaining ability of creature variety, ability of resisting natural calamity, and the ability of resisting pollution and so on; the land ecosystem's health can be assessed by the ability of resisting pollution, maintaining ability of the variety of soil creature (mainly microbe), buffer ability of the soil's acid and its alkali, ability of keeping water, and the continuously maintaining ability of nutrient elements and so on (Rapport *et al.* 1998); the water ecosystem's health can be evaluated by the indicating creature species (such as float creature, benthos invertebrate, the most nutritious creature, the most susceptible creature, etc.) (Ma *et al.* 2000) and the index-system methods such as the method of ecological pathology, method of epidemiology, method of veterinary, method of bio-pharmacology, experimental method of completely testing water ecosystem, and the synthetic method of the social economic index and ecological index. For assessing ecosystem health, firstly, some parameters that can represent the main characteristics of ecosystem should be chosen; secondly, these characteristics should be classified and distinguished, and the meaning of each characteristics should be defined; thirdly, these characteristic elements should be evaluated, and the weight coefficient of each characteristic element in ecosystem health should be determined; finally, the assessment method of ecosystem health should be determined, and the assessment system of ecosystem health is established. For the ecosystems in different regions and different types of ecosystems, their characteristic elements, the weight of every single characteristic element, the weight of every type of characteristic element and the assessment index system are different, as the organization, progressing law, service target and management aim of ecosystem are different (Riki *et al.* 1992). To assess ecosystem's health, the indexes should be based on the maintaining ability of ecosystem's organization, function process of ecosystem, and the resilience under ecosystems coercion. In general, they may be classified into five types: vigor of ecosystem, organization of ecosystem, capacity of ecosystem, resilience of ecosystem, and irradiation of ecosystem. Each type of index also includes different specific factors (Fig.1).

Strategic environmental assessment for ecosystem health

Potential advantages of SEA for ecosystem health

For achieving ecological sustainability, it is necessary to keep and maintain ecosystem health. Only when ecosystem possesses the operation's stability and sustainability, can it ensure ecological sustainability. Therefore, ecosystem health should be integrated into the system of SEA, and ecosystem health should be looked as the ecological sustainability target of SEA.

Comparing EIA with SEA for ecosystem health, it is found that SEA for ecosystem health has more potential advantages in achieving ecological sustainability target than EIA.

In general, the deficiencies of project-level SEA are as follows:

(1) It is not a proactive forecast, but a reactive assessment for the environmental impacts of a project, which makes its function limited both in the selection of development projects and in the optimization of their layout, so it can only provide some measures for mitigating, for example, pollution.

(2) The assessment for the environmental impacts of a project often falls behind the making of strategic decisions. In the phase of environmental impact assessment of a project, most decisions have already been made in the former planning phases. EIA is limited both in the available schemes' selection of projects and in the selection of preventing for preventing pollution.

(3) In general, project-level EIA is difficult to analyze cumulative environmental effects of many construction projects (including accumulations both in time and space), the synergistic effects of different kinds of pollution, and the induced or indirect environmental effects.

(4) Project-level EIA is difficult to analyze large-scale environmental impacts and the global impacts, such as the greenhouse gas effects and damage to the biodiversity.

(5) Project-level EIA scarcely integrates environmental, social and economical factors into a system.

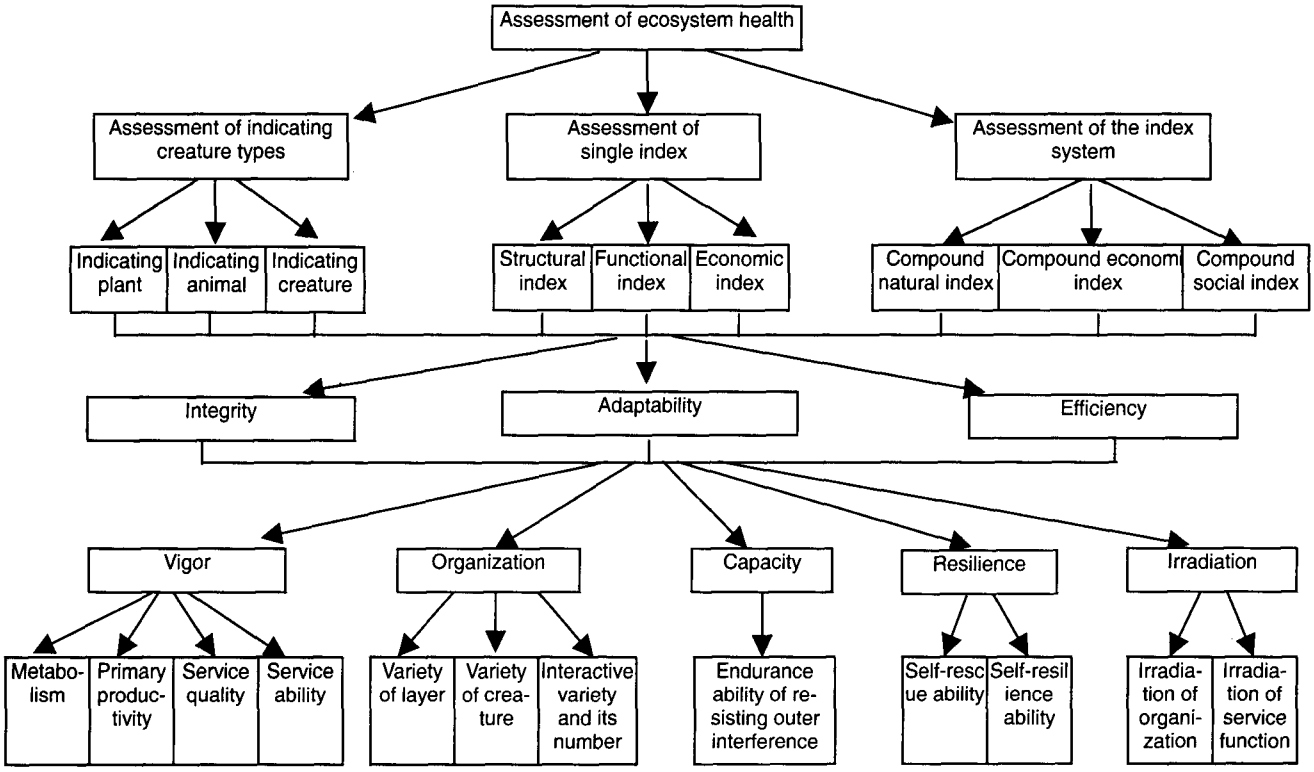

Fig. 1 The assessment system of ecosystem health

In theory, the potential advantages of SEA for ecosystem health are as follows (Shepherd 1996; Therivel 1996; Wicklum 1995): (1) SEA can provide a systematic and comprehensive framework in which the principles of sustainable development can be implemented by applying them in the decision-making process; (2) SEA is an assessing process including multiple layers, so the principles of sustainable development can be carried out in any layer from policy, program and plan to the specific project; (3) SEA is proactive in that it can forecast the specific impacts of the policy, program and plan on environment in the early phase; (4) the cumulative environmental effects resulting from multiple development projects from higher levels can be analyzed by SEA for supporting the management of projects; (5) SEA can effectively supervise governmental decisions' suitability for environmental management and provide the effective measures to ease impact; (6) we can carry out the real consultation of experts and participation of the public early through SEA and give more attention to the advantages of group decision, so as to make the decision more scientific and more reasonable; (7) SEA emphasizes the process rather than the final product, aiming to reduce the adverse impacts of the final decision on the environment.

Framework of SEA for ecosystem health

The assessment system of ecosystem health should be looked as a general assessment target system of SEA, and then the framework of SEA should be reestablished.

In brief, strategic environmental assessment for ecosys-

tem health is a process in which the criteria being beneficial to ecosystem should be met, and the environmental impacts of strategic decisions and their available alternatives should be systematically and comprehensively assessed. Some basic principles are as follows:

(1) *The principle of target-orientation based on ecosystem health.* "Ecological sustainability" is an extremely wide concept, and the analysis on the factors of environmental impacts is also rather complex system engineering. SEA currently conducted often fails to totally and universally analyze environmental impacts due to short of a general assessment system, so the effectiveness and practicality of SEA are poor. Ecosystem health is the fundamental guarantee of ecological sustainability. Ecosystem health has possessed a systematic and scientific assessment system, which can be integrated into SEA to guide decision-makers to making suitable indigenous means and local solutions.

(2) *The flexibility principle of the weight's regulating of assessment index for objective.* The different "policies", "programs" and "plans" formulated by government are for different objects. The crucial limiting factors for realizing ecosystem health of the different objectives are different. Therefore, the practical application of assessment index system of ecosystem health must follow the principle of the weights regulating flexibly of assessment index, thus ensuring both the focal point of assessment and the overall situation of assessment. For example, if the government wants to formulate a developing program of coastal zoo, it should consider that, as a region of coastal zoo with the functional structure of multiple natural safeguards and the fast development of economy, the endurance ability of the environment and resources might become a crucial limiting factor of realizing the target of ecosystem health. Only recognizing the endurance ability of the regional environment and resources, can we settle the issues on the cumulative, repeated, long-term and endurable impacts and offer the really helpful information to decision-makers. So, in the practical assessment of development programs, we should make the endurance ability of resisting outer interference act as the main assessment index, and at the same time, consider other indexes, and then comprehensively assess the program.

(3) *The principle of the consultation of experts and participation of the public.* The consultation of experts and the participation of the public are helpful to making SEA more scientific and more reasonable. In the process of practical environmental impact assessment, there may be some special and technical problems, for example, how to value the environmental assessment index, how to weigh the environmental assessment index and so on. These crucial problems in the assessment process all need to consult experts. Satisfying the requirement of the public's material and spiritual life is an inevitable element of ecosystem health. SEA for ecosystem health should extensively ask for opinion of the public, and embody their value. In addition, the participation of the public is also helpful to offering the most useful environmental information to the evaluator and effectively supervising the assessing process.

Under the guide of the above principles, the assessing process of SEA for ecosystem health is as follows (Fig.2):

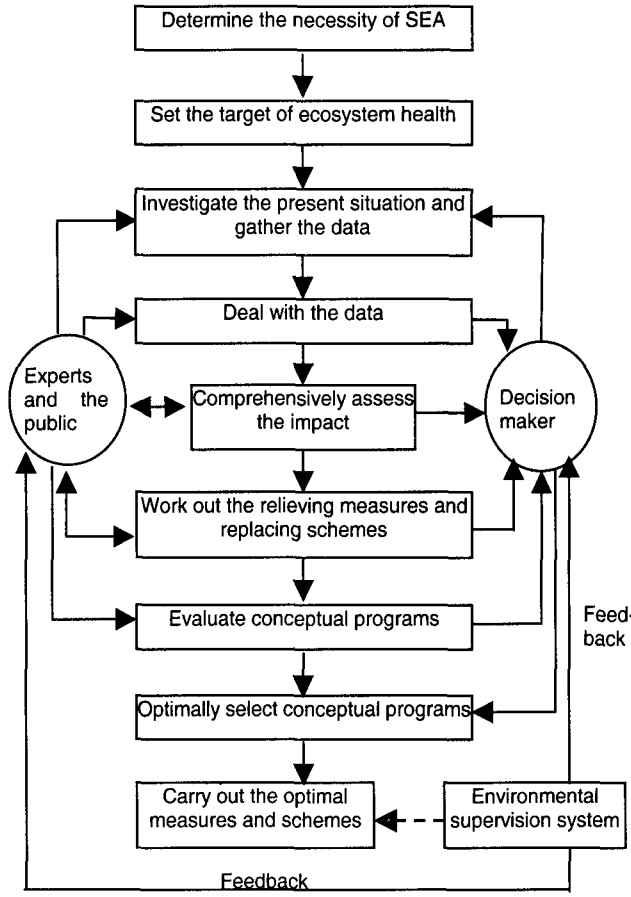

Fig.2 The procedure of SEA for ecosystem health

Conclusions

SEA is introduced into assessment system to counteract the limitations of project-level EIA. SEA' target is to promote sustainable development including social sustainability, economic suitability and ecological sustainability. Ecological sustainability, among these three targets, is the most fundamental target. Good ecological sustainability principles should be provided with distinct content and a general assessment system. Ecosystem health provides a new perspective for human ecological sustainability, whose assessment system is helpful to guiding decision-makers to make suitable indigenous means and local solutions, once ecosystem health is integrated into the system of SEA, SEA for ecosystem health has many advantages over project-level EIA. SEA for ecosystem health has a set of its own principles and procedure, which should be strictly followed.

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